CHAPTER 8

MAP READING

8-1. **MAIN OBJECTIVE: Given a map, protractor, scratch paper, pencils, questions, and lists of correct and incorrect responses,, select the correct response for each question by applying basic map reading knowledge and skills.**

REFERENCE: FM 21-26.

NOTE

A 1:50,000 Harlem, Georgia map, protractor, scratch paper, and pencils will be provided to each candidate for use during the written test.

8-2. **Given a location on the Harlem, Georgia map sheet and a list of counties, select the correct county.**

In order to select the correct county, you will have to go to the Marginal Information placed around the outer edges of the map. All maps are not the same so it becomes necessary every time-a different map is used to examine the marginal information carefully. In this case, using a 1:50,000 scale map, refer to the Index to Boundaries in the lower right margin. This diagram which is a miniature of the map shows the boundaries of county lines and states boundaries. on some maps, boundary information is located in the Location Diagram.

Find the location referenced in the question and then refer to the Index to Boundary Information to select the correct county.

The index to Boundaries diagram appears in the lower or right margin of all sheets 1:100,000 scale or larger, and 1:1,000,000 scale. This diagram, which is a miniature of the map, shows the boundaries which occur within the map area, such as county lines and state boundaries. Of 1:250,000 scale maps, the boundary information is included in the location diagram. See Figure 8-1.

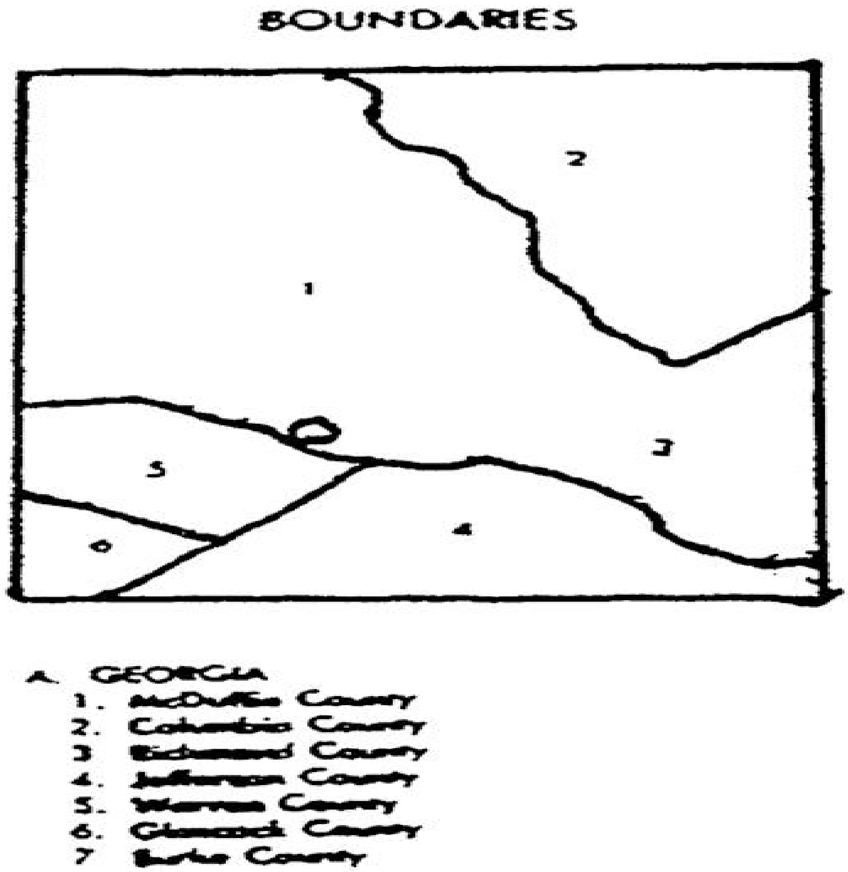

Figure 8-1. Index to Boundaries

8-3. **Given a location not on the Harlem, Georgia map sheet and a list of adjoining sheet numbers, select the adjoining sheet number where the location will be found.**

To locate the correct adjoining sheet number where a location will be found: first, locate the sheet number (found in the upper or right margin) This is used as a reference number for that map sheet.

Second, locate the map series name (found in the upper left margin). A map series usually comprises a group of similar maps at the same scale and on the same sheet lines or format designed to cover a particular geographic area. It may also be a group of maps to serve a common purpose, such as the military city maps. (Refer to the Figure 8-2).

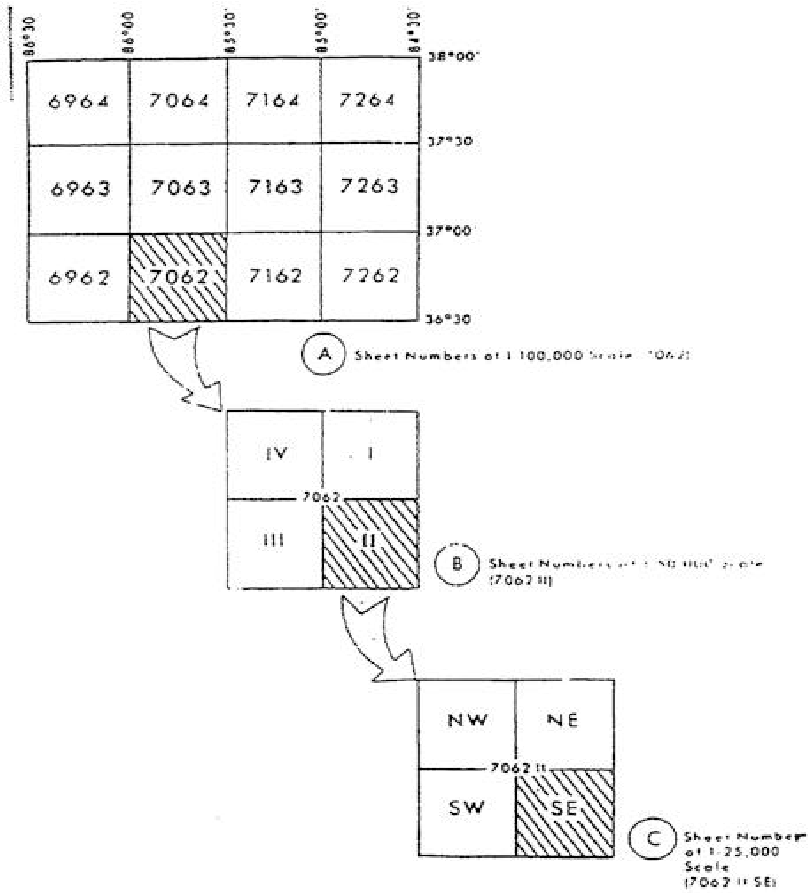

Figure 8-2. Sheet Numbers

On some recent 1:50,000 scale maps, the map credits are shown in tabular form in the lower margin, with reliability information presented in a coverage diagram.

a. Adjoining sheets diagram. Maps at all standard scales contain a diagram which illustrates the adjoining sheets.

(1) On maps at 1:100,000 and larger scales and at 1:1,000,000 scale, the diagram is called the Index to Adjoining Sheets, and consists of as many rectangles, representing adjoining sheets, as are necessary to surround the rectangle which represents the sheet under consideration. The diagram usually contains nine rectangles, but the number may vary depending on the locations of the adjoining sheets. All represented sheets are identified by their sheet numbers. Sheets of an adjoining series, whether published or planned, that are at the same scale are represented by dashed lines. The series number of the adjoining series is indicated along the appropriate side of the division line between the series
(Figure 8-3).

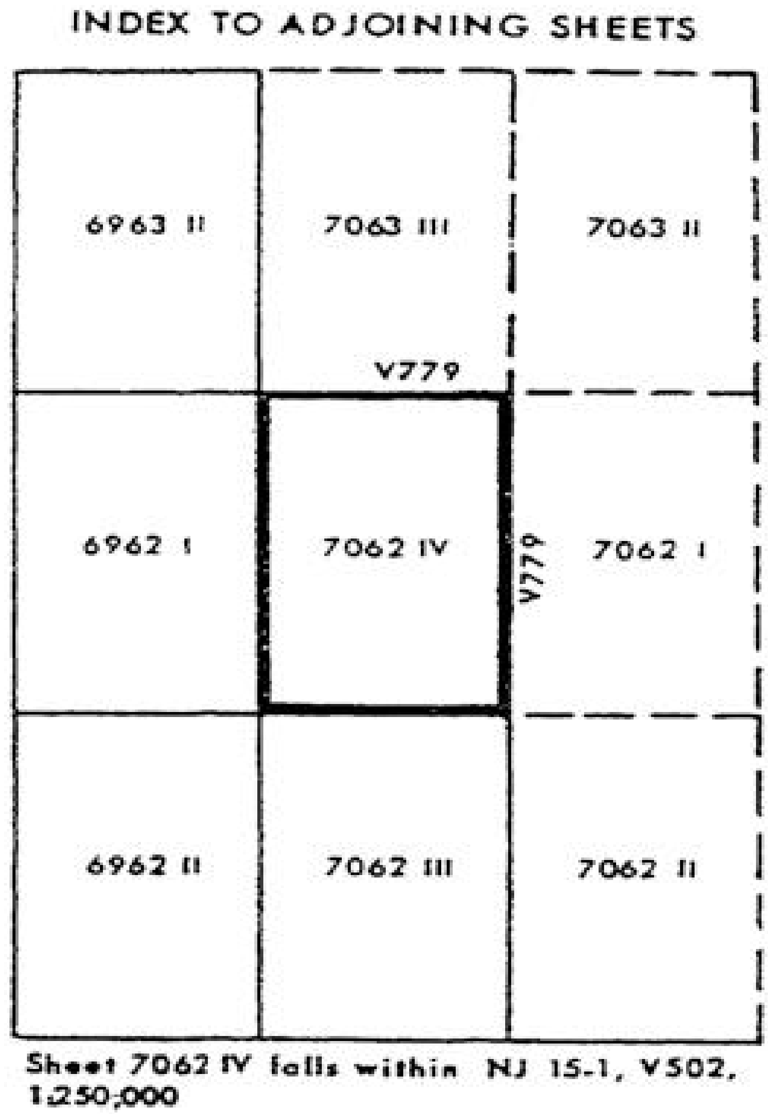

Figure 8-3. Index to Adjoining Sheets

(2) On 1:50,000 scale maps, the sheet number and series number of the 1:250,000 scale map of the area are shown in Figure 8-4.

(3) On maps at 1: 250,000 scale, the adjoining sheets are shown in the Location Diagram. Usually, the diagram consists of 25 rectangles, but the number may vary with the locations of the adjoining sheets.

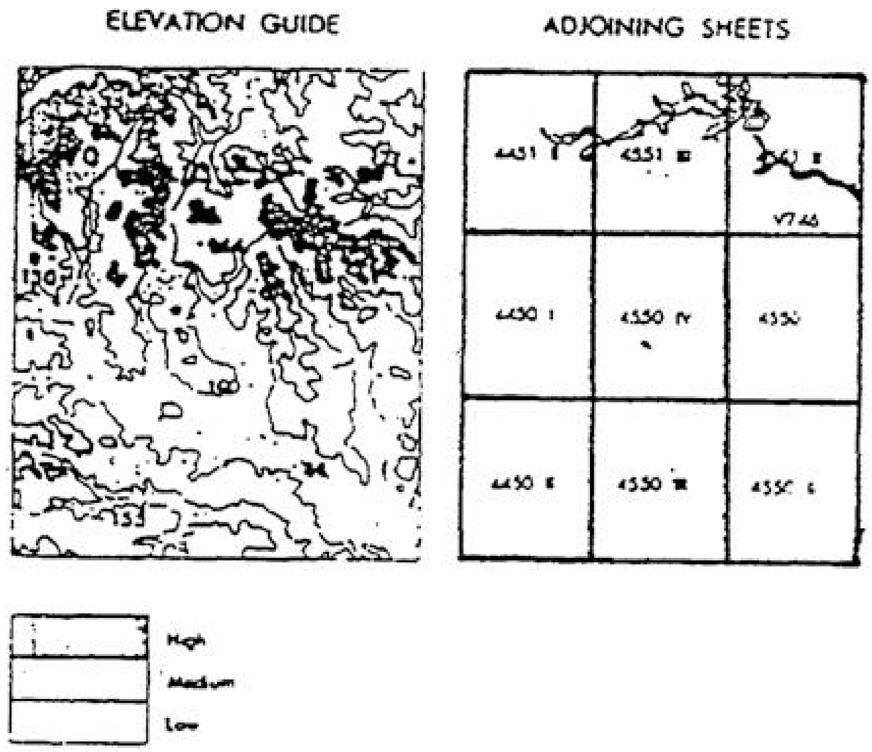

Figure 8-4. Elevation Guide; Adjoining Sheets

8-4. **Given a location, terrain feature, or man-made object, and a list of four eight-digit grid coordinates, select the correct grid coordinate for that location, terrain feature, or man-made object, to within 50 meters.**

8-5. **Given eight-digit grid coordinates and a list of terrain features or man-made objects, select the correct feature or object.**

When selecting grid coordinates of a given location, terrain feature, map, and western read up You now problem or man-made object, first, read across the bottom of the find the numbered line that borders the closest left or boundary line of the feature you are identifying; next, the map to the closest southern or bottom boundary line. You now have four of the eight digits necessary to solve the (see Figure 8-5).

NOTE

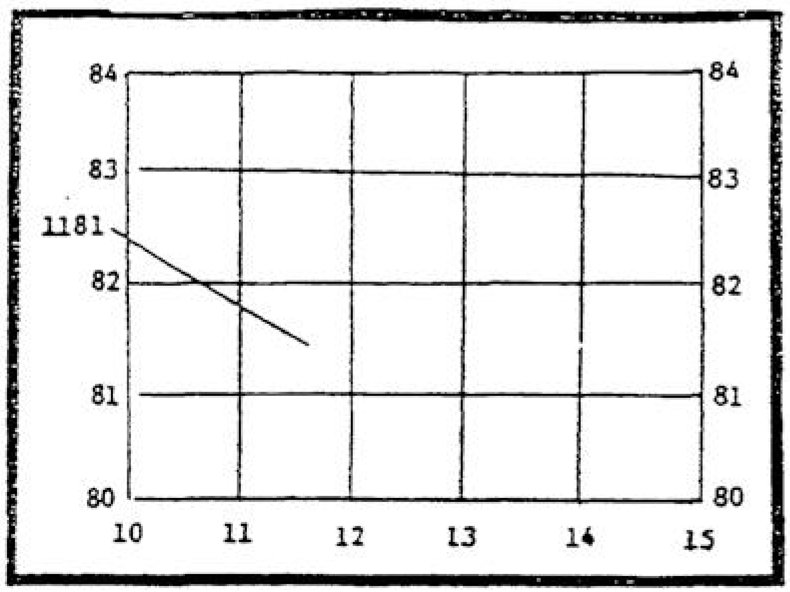

Figure 8-5. Grid Map

For the purpose of the EFMB, eight digit grid coordinates are required

The designation of a point is based on the military principle: Read RIGHT, then UP. The precision desired determines the number of digits to be read beyond the principal digits. It should be impressed upon the reader that the term "grid coordinate" of ten includes both the 100,000 meter square identification and the desired number of digits. In many instances, it is a tactical requirement that the 100,000 meter square identification be included in any point designation.

a. Reading RIGHT-UP, coordinates 1484 locate the 1000-meter grid square in which point X is located. The next square to the right would be 1584; the next square up would be 1485; etc.

b. To locate the point to the nearest 10 meters, estimate the tenths of the grid square from grid line to point, in the same order (RIGHT-UP). Give complete coordinate RIGHT, then complete coordinate UP. This point is about two tenths of a grid square right and about one tenth up; coordinates to the nearest 100 meters are 142841.

c. Artillery requirements usually call for location of the target within at least 10 meters (about 35 feet). To locate the point to the nearest 10 meters, use a scale to measure the hundredths of a grid square RIGHT and UP from grid line to point. This point is 17 hundredths right and 9 hundredths up; coordinate to the nearest 10 meters are 14178409 (always prefix a zero if the hundredths reading is less than 10).

d. On maps of very large scales, and under special conditions, it may be desirable to locate a point within one meter. This is done by measuring the thousandths of a grid interval from line to point.

e. The precision of a point reference is shown by the number of digits in the coordinates--the more digits, the more precise the location.

1484	-	a 1,000 meter grid square.
142841	-	to the nearest 100 meters.
14178409	-	to the nearest 10 meters.
1416884087	-	to the nearest meter.

f. If a scale is not available that exactly divides the side of the grid square in tenth or hundredths, these divisions may be made by slanting the scale until it fits the interval between grid lines as explained under measurement of geographic coordinates.

g. Coordinates are written as one continuous number without spaces, parentheses, dashes, or decimal points. From this, it should be obvious that whoever is to use the written coordinates must know where to make the split between the RIGHT reading and the UP reading; for this reason, the coordinates of the point within the 100,000-meter square must always contain an even number of digits.

8-6. **Given a location on the Harlem, Georgia map sheet and a list of elevations, select the correct elevation above mean sea level of the location.**

Contour Lines.

a. There are several ways of indicating elevation and relief on maps. The most common way is by contour lines. A contour line is a line representing an imaginary line on the ground along which all points are at the same elevation.

b. Contour lines indicate a vertical distance above or below a datum plane. Starting at sea level, normally the zero contour, each contour line represents an elevation above sea level. The vertical distance between adjacent contour lines is known as the contour interval and the amount of the contour interval is given in the marginal information. On most maps, the contour lines are printed in brown. Starting at zero elevation, every fifth contour line is drawn with a heavier line. These are known as index contours and some place along each index contour the line is broken and its elevation is given. The contour lines falling between index contours are called intermediate contours. They are drawn with a finer line than the index contours and usually do not have their elevations given.

c. Using the contour lines on a map, the elevation of any point may be determined by:

(1) Finding the contour interval of the map from the marginal information and noting both the amount and the unit of measure.

(2) Finding the numbered contour line (or other given elevation) nearest the point for which the elevation is being sought.

(3) Determining the direction of slope from the numbered contour line to the desired point.

(4) Counting the number of contour lines that must be crossed to go from the numbered line to the desired point and noting the direction--up or down. The number of lines crossed multiplied by the contour interval is the distance above or below the starting value.

(a) If the desired point is on a contour line, its elevation is that of the contour.

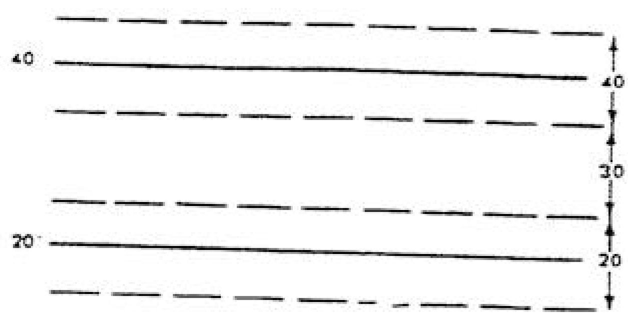

Figure 8-6. Estimating Elevations Between Contour Lines

(b) For a point between contours, most military needs are satisfied by estimating the elevation to an accuracy of one half the contour interval. All points less than one-fourth the distance between the lines are considered to be at the same elevation as the line. All points one-fourth to three-fourths the distance from the lower line are considered to be at an elevation one-half the contour interval above the lower line (Figure 8-6). If a more precise determination of elevation is needed, or if the contours are very widely spaced, the elevation of the point may be interpolated to the accuracy desired.

(c) To estimate the elevation of the top of an unmarked hill, add half the contour interval to the elevation of the highest contour line around the hill.

(d) To estimate the elevation of the bottom of a depression, subtract half the contour interval from the value of the lowest contour around the depression.

d. On maps where the index and intermediate contour lines do not show the elevation and relief in as much detail as may be needed, supplementary contours may be used. These contour lines are dashed brown lines, usually at one-half the contour interval for the map. A note in the marginal information indicates the interval used. They are used exactly as are the solid contour lines.

e. On some maps, the contour lines may not meet the standards of accuracy, but are sufficiently accurate in both value and interval to be shown as contours rather than as form lines. In such cases, the contours are considered as approximate and are shown with a dashed symbol; elevation values are given at intervals along the heavier (index contour) dashed lines. The contour note in the map margin identifies them as approximate contours.

f. In addition to the contour lines, bench marks and spot elevations are used to indicate points of known elevation on the map. Bench marks, the more accurate of the two, are symbolized by a black X ' as X BM 124. The elevation value shown in black refers to the center of the X. Sport elevations shown in brown generally are located at road junctions, on hilltops, and other prominent landforms. The symbol designates an accurate horizontal control point. When a bench mark and a horizontal control point are located at the same point, the symbol BM is used.

g. The spacing of the contour lines indicates the nature of the slope.

(1) Contour lines evenly spaced and wide apart indicate a uniform, gentle slope (Figure 8-7).

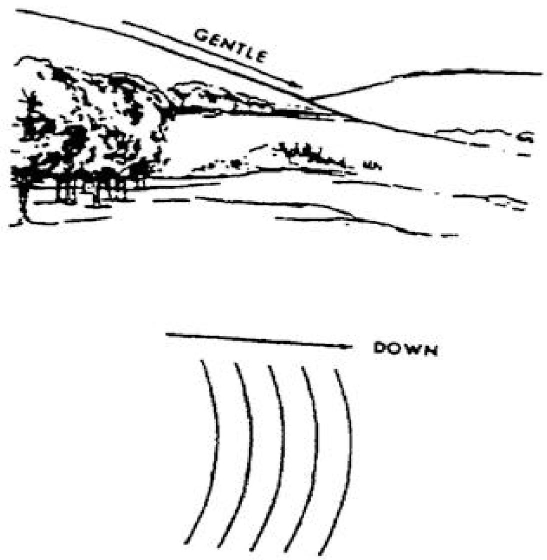

Figure 8-7. Uniform Gentle Slope

(2) Contour lines evenly spaced and close together indicate a uniform, steep slope. The closer the contour lines to each other, the steeper the slope (Figure 8-8).

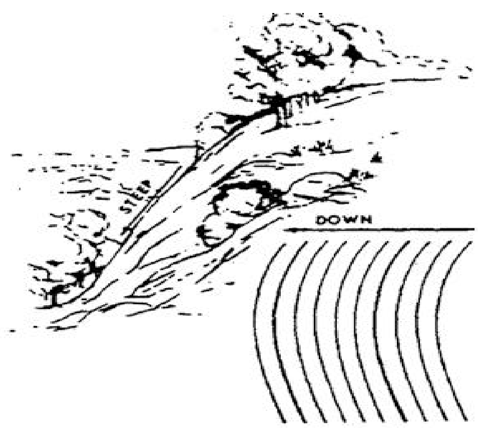

Figure 8-8. Uniform Steep Slope

(3) Contour lines closely spaced at the top and widely spaced at the bottom indicate a concave slope (Figure 8-9). Considering relief only, an observer at the top of a concave slope can observe the entire slope and the terrain at the bottom. Conversely, a unit attacking up such a slope would have no cover or concealment from observers or weapons at or near the top; also, the farther up the slope, the more difficult is the climb.

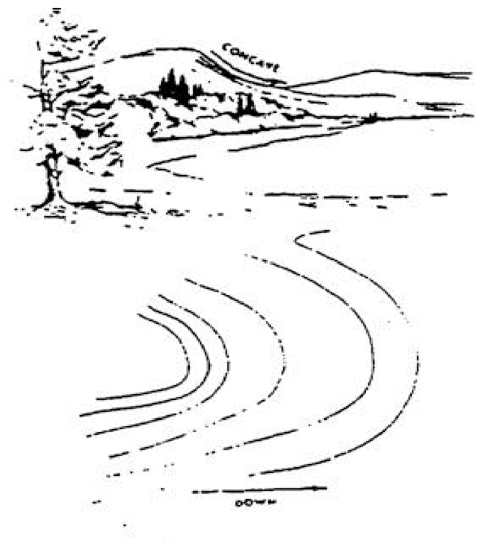

Figure 8-9. Concave Slope

(4) Contour lines widely spaced at the top and closely spaced at the bottom indicate a convex slope (Figure 8-10). An observer at the top of a convex slope has no observation of most of the slope or of the terrain at the bottom. Conversely, a unit attacking up such a slope has a much greater degree of cover and concealment than on a concave slope; also, the farther up the slope, the easier is the climb.

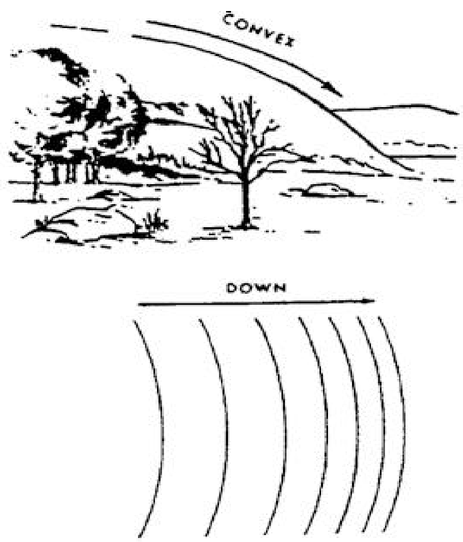

Figure 8-10. Convex Slope

h. In order to show the relationship of the land formations to each other and how they would be symbolized on a contour map, stylized panoramic sketches of the major relief formations were drawn and a contour map of each sketch developed. Each of Figures 8-11 thru 8-18 shows a sketch and map with a different relief feature and its characteristic contour pattern.

(1) Hill: A point or small area of high ground (Figure 8-11). When you are located on a hilltop, the ground slopes down in all directions.

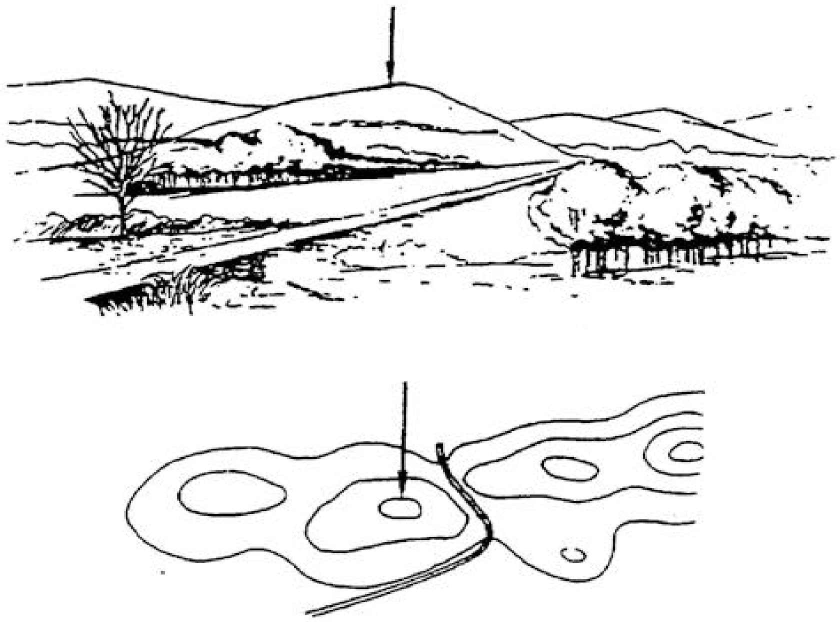

Figure 8-11. Hilltop

(2) Valley: A stream course which has at least a limited extent of reasonably level ground bordered on the sides by higher ground (a, Figure 8-12). The valley generally has maneuver room within its confines. Contours indicating a valley are U-shaped and tend to parallel a major stream before crossing it. The more graduate the fall of a stream, the farther each contour parallels it. The curve of the contour crossing always points up-stream.

(3) Draw: A less-developed stream course in which there is essentially no level ground and therefore, little or no maneuver room within its confines (b, Figure 8-12). The ground slopes upward on each side and towards the head of the draw. Draws occur frequently along the sides of ridges, at right angles to the valleys between them. Contours indicating a draw are V-shaped, with the point of the "VI," toward the head of the draw.

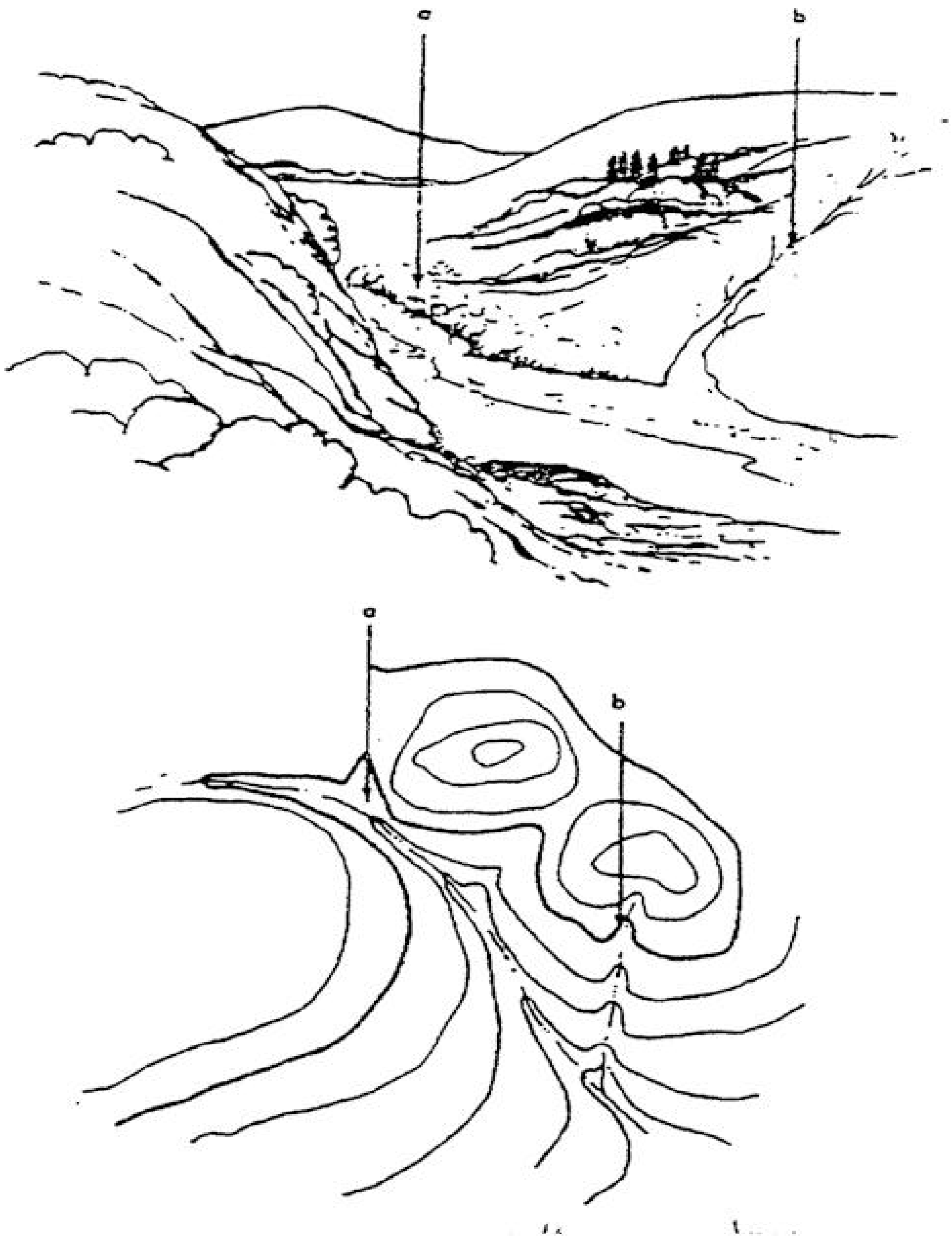

Figure 8-12. a. Valley; b. draw

(4) Ridge: A line of high ground with normally minor variations along its crest (a, future 8-13). The ridge is not simply a line of hills; all points of the ridge crest are appreciably higher than the ground on both sides of the ridge.

(5) Spur: A usually short, continuously sloping line of higher ground normally jutting out from the side of a ridge (b, Figure 8-13). A spur is often formed by two roughly parallel streams cutting draws down the side of a ridge.

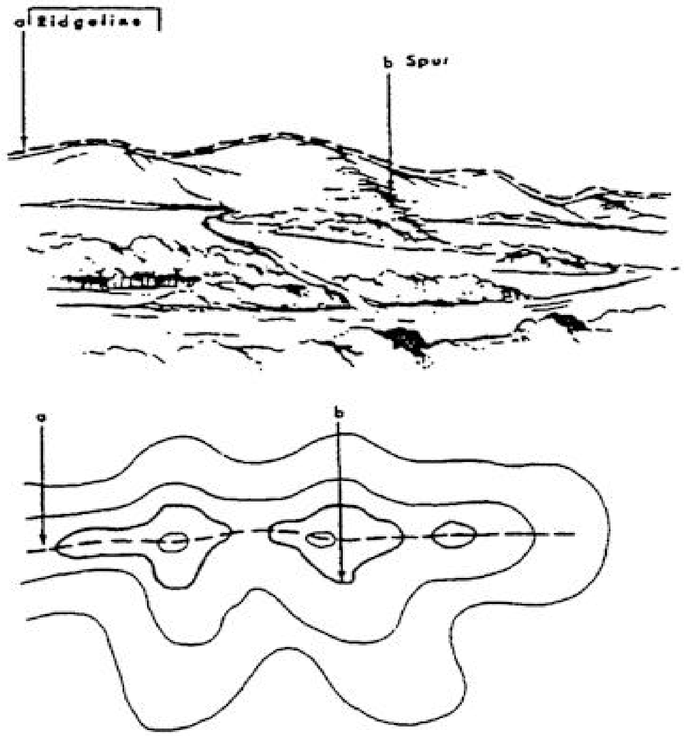

Figure 8-13. a. Ridge; b. Spur

(6) Saddle: A dip or low point along the crest of a ridge. A saddle is not necessarily the lower ground between two hilltops; it may be simply a dip or break along an otherwise level ridge crest (Figure 8-14).

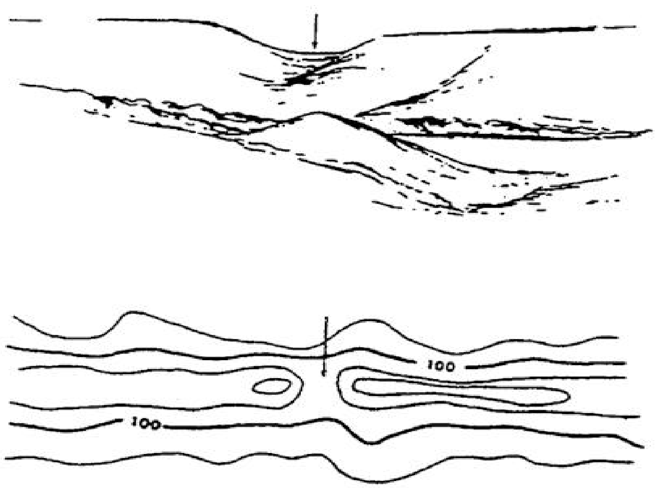

Figure 8-14. Saddle

(7) Depression: A low point or sinkable, surrounded on all sides by higher ground (Figure 8-15).

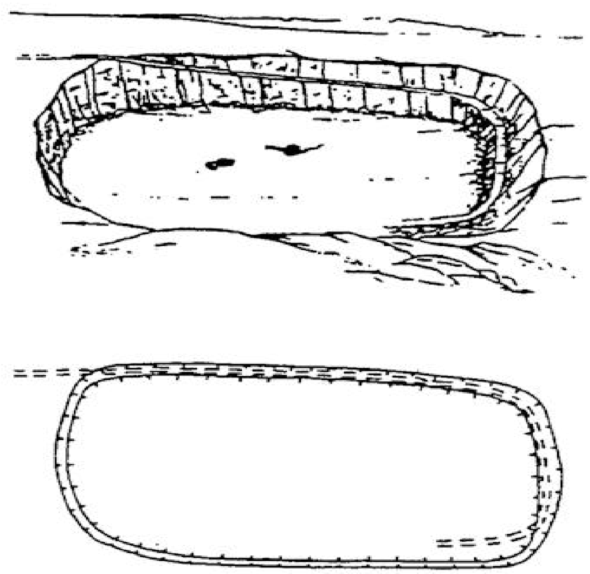

Figure 8-15. Depression

(8) Cuts and fills: Man-made features by which the bed of a road or railroad is graded or leveled off by cutting through high areas (a, Figure 8-16) and filling in low areas (b, Figure 8-16) along the right-of-way.

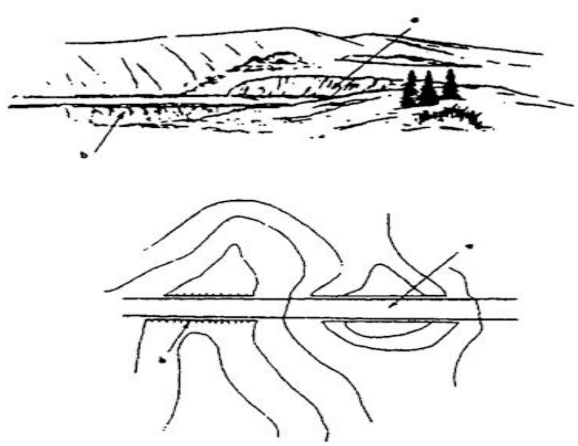

Figure 8-16. a. Cut; b. Fill

(9) Cliff: A vertical or near vertical slope (Figure 8-17). When a slope is so steep that it cannot be shown at the contour interval without the contours joining together, it is shown by a ticked "carrying" contour or contours. The ticks always point toward lower ground. The rate of rise or fall of a ground form is known as its slope, and may be described as being steep or gentle. The question arises as to how steep or

Figure 8-17. Cliff

how gentle. The speed at which equipment or personnel can move is affected by the slope of the ground. (Most equipment has a limit as to how steep it can negotiate terrain.) Because of this, a more exact way of describing a slope is demanded. Slope may be expressed in several ways, but all depend upon a comparison of vertical distance (VD) to horizontal distance (HD) (Figure 8-18). VD is the difference between the highest and lowest elevations in the slope and is determined from the contour limes. HD is the horizontal ground distance between the highest and the lowest elevations of the slope. The VD and HD must be expressed in the same units. Both measurements must be made with extreme accuracy in order to have a valid determination of how steep terrain actually is.

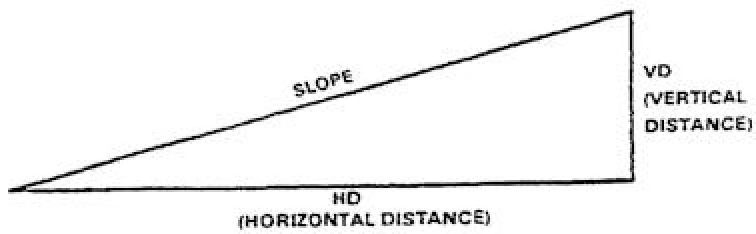

Figure 8-18. Slope Diagram

8-7. **Given two locations and a list of elevation differences, select the correct difference in elevation between the two points.**

For this type of problem, you will have two problems to solve. The first is to locate a point (in this case, two points). Next, find the first point's elevation by using the contour lines closest to this point; then locate the second point's elevation by using the contour lines nearest the second point. Subtract the smaller number from the larger number to find out which point is higher and by how much.

8-8. **Given a back azimuth and a list of azimuths, select the correct azimuth.**

8-9. **Given an azimuth and a list of back azimuths, select the correct back azimuth.**

8-10. **Given a declination, a grid azimuth, and a list of magnetic azimuths, select the correct magnetic azimuth.**

8-11. **Given a declination, a magnetic azimuth, and a list of grid azimuths, select the correct grid azimuth.**

8-12. **Given a grid azimuth and a list of magnetic azimuths, select the correct magnetic azimuth to follow in the Harlem, Georgia area.**

8-13. **Given a magnetic azimuth and a list of grid azimuths, select the correct grid azimuth to plot on the Harlem, Georgia map sheet.**

8-14. **Given two locations and a list of grid azimuths or back azimuths, select the correct grid or back azimuth between the two locations.**
8-15. **Given two locations and a list of magnetic azimuths or back azimuths, select the correct magnetic or back azimuth between the two locations.**

Objectives 8-7 thru 8-14 deal with azimuths (grid azimuths, magnetic azimuths, or true azimuths) and one's ability to use them in order to locate specific positions. You will have to be able to convert from magnetic to true and visa versa; locate grid azimuths while considering magnetic azimuths; convert grid azimuths to magnetic azimuths and visa versa; find the back azimuth between two locations; and, finally, select the correct magnetic azimuth or back azimuth between two given locations.

In order to measure anything, there must be a starting point or zero measurement. To express a direction as a unit of angular measure, there must be a starting point or zero measurement and a point of reference. These two points designate the base or reference line.

There are three base lines--true north, magnetic north, and grid north. Those most commonly used are the magnetic north and grid north. Normally, when working with the compass, the magnetic north is the most often used; when working with a map, the grid north is the most of ten used. The following working definitions should be committed to memory:

a. True North--a line from any position on the earth's surface to the north pole. All longitude lines are true north lines. On Army maps, true north is usually symbolized by a star (see Figure 8-19).

b. Magnetic North--the direction to the north magnetic pole. The direction of north seeking needle of a magnetic instrument indicates is usually symbolized by a half arrowhead (see Figure 8-19).

c. Grid North--the vertical (up and down) grid lines on a map. They are symbolized sometimes by the letters GN or the letter Y

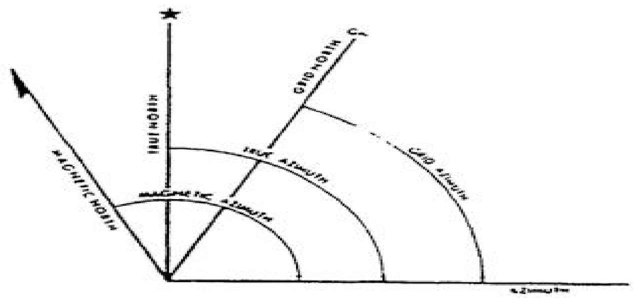

Figure 8-19. True, Grid, and Magnetic Azimuths

The most common military method of expressing a direction is by using azimuths. An azimuth is defined as a horizontal angle, measured in a clockwise manner from a north base line. When the azimuth between two points on a map is desired, the points are joined by a straight line and a protractor is used to measure the angle between grid north and the drawn line. This measured angle is the grid azimuth of the drawn line (Figure 8-20). When using an azimuth, the point from which the azimuth originates is imagined to be the center of the azimuth circle (Figure 8-21). Azimuths take their name from the base line from which they have been measured; true azimuths from true north, magnetic azimuths from magnetic north, and grid azimuths from grid north (Figure 8-22). Therefore, any one given direction can be expressed in three different ways: a grid azimuth if measured on a military map, a magnetic azimuth if measured by a compass, or a true azimuth if measured from a meridian of longitude.

A back azimuth is the reverse direction of an azimuth. It is comparable to doing an "about face." To obtain a back azimuth from an azimuth, add 1800 if the azimuth is 180' or less, or subtract 1800 if the azimuth is 1800 or more. The back azimuth of 180' may be stated as either 00 or 3600.

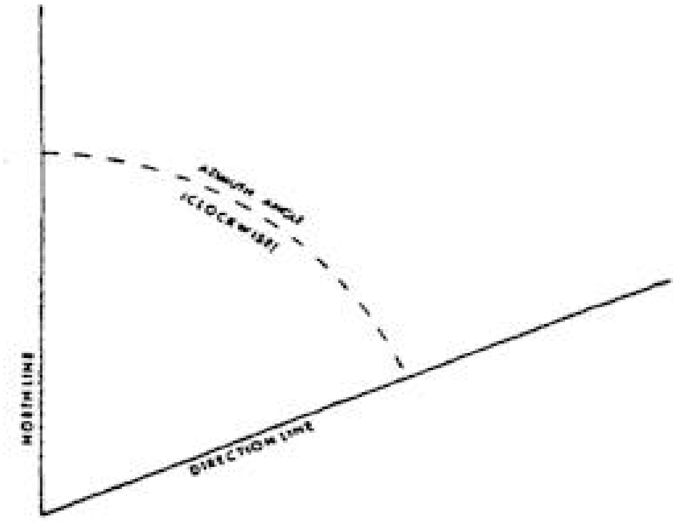

Figure 8-20. Azimuth Angle

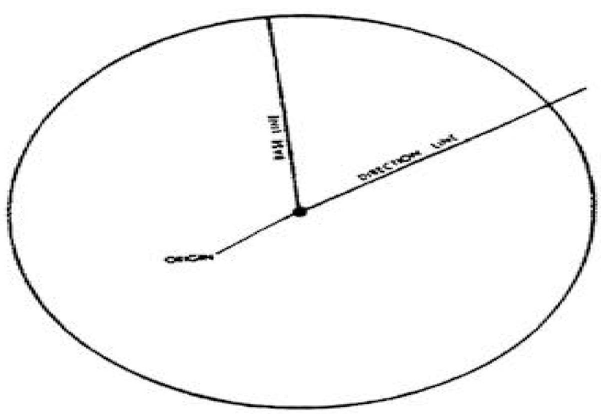

Figure 8-21. Origin of Azimuth Circle

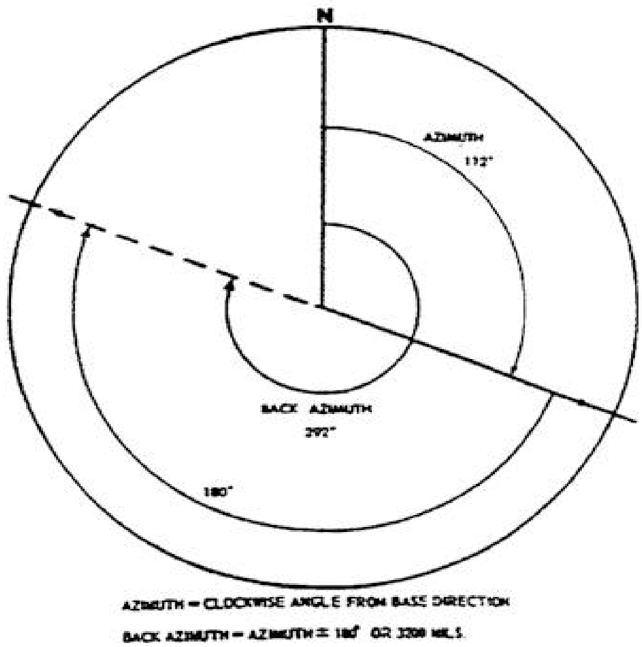

Figure 8-22. Azimuth and Back Azimuth

A declination diagram is placed on most large-scale maps to enable the user to orient the map properly. The diagram shows the interrelationship of magnetic north, grid north, and true north. On medium-scale maps declination information is shown by a note in the map margin.

Declination is the angular difference between true north and either magnetic or grid north. There are two declinations, a magnetic declination and a grid declination.

The declination diagram contains three prongs representing magnetic north, grid north, and true north (Figure 8-23).

a. G-M Angle. An arc, indicated by a dashed line, connects the grid north and the magnetic north prongs. The value of this arc, the grid-magnetic angle (G-M ANGLE), states the size of the angle between grid north and magnetic north and the year it was prepared. This value is expressed to the nearest 1/20, with mil equivalents shown to the nearest 10 mils.

b. Grid Convergence. An arc, indicated by a dashed line, connects the prongs for true north and grid north. The value of the angle for the center of the sheet is given to the nearest full minute with its equivalent to the nearest mil. These data are shown in the form of a grid convergence note.

c. Conversion Notes. Notes may also appear in conjunction with the diagram explaining the use of the G-M angle. One note provides instructions for converting magnetic azimuth to grid azimuth and the other note, for converting grid azimuth to magnetic azimuth. The conversion (add or subtract) is governed by the direction of the magnetic north prong relative to that of the grid north prong.

The grid north prong is always aligned with the easting grid lines on the

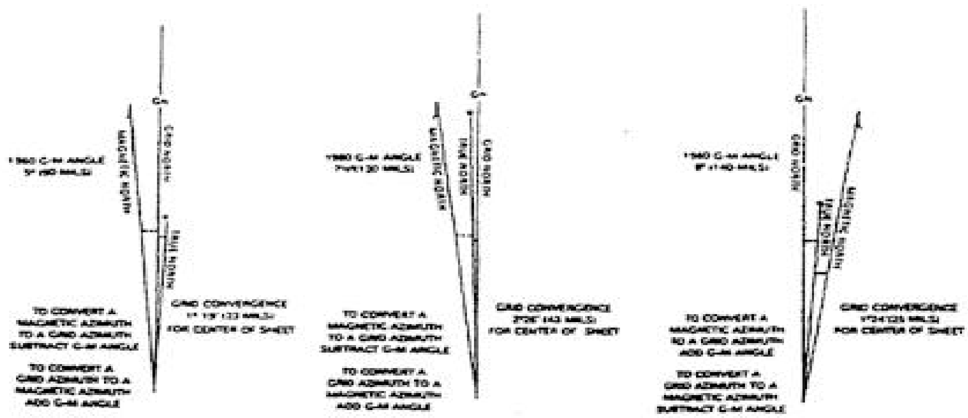

Figure 8-23. Declination Diagrams

map, and on most maps is formed by an extension of an easting grid line into the margin. The angles between the prongs, however, are seldom plotted exactly. The relative position of the directions is obtained from the diagram, but the numerical value should not be measured from it. For example, if the amount of declination from grid north or magnetic north is 10, the arc shown in the diagram may be exaggerated; if measured, it may have an actual value of So. The position of the three prongs in relation to each other varies according to the declination data for each map.

It is often necessary to convert from one type of direction to another. A magnetic compass reading gives a magnetic azimuth, but to plot this line on a map with grid lines, the magnetic azimuth value must be changed to a grid azimuth. The reverse is true when orientation is taken from the map; the grid azimuth measured from the map must be converted to a magnetic azimuth for use with the magnetic compass. The declination diagram is used for these conversions. Most maps include with the diagram the grid-magnetic (G-M) angle and notes explaining its use to convert from one azimuth to another. on older sheets which do not show this information, it is necessary to determine whether to add or subtract the difference to the given azimuth to obtain the desired one. A rule to remember when solving such problems is this: <u>no matter where the azimuth line points, the angle to it is always measured clockwise from the reference direction</u> (base line). With this in mind, the problem is solved in three easy steps:

a. Examine the declination diagram on the map (Figure 8-24).

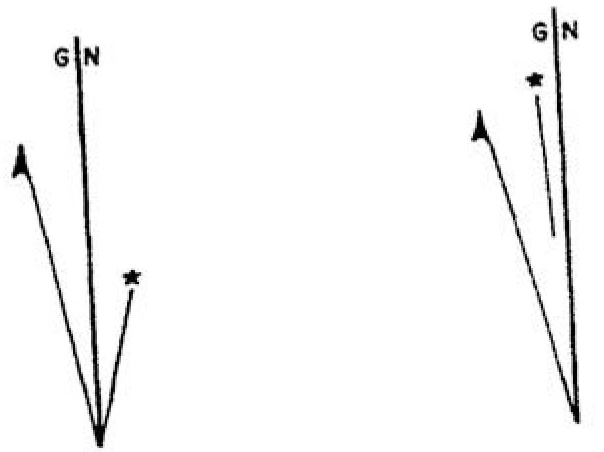

Figure 8-24. Declination Diagrams

b. From the apex of the declination diagram, draw an arbitrary line at roughly right angles to the general direction of north, regardless of the actual value of the azimuth in degrees (Figure 8-25). The position of the arbitrary line in relationship to the declination diagram is of little importance. Figure 8-26 shows an arbitrary line drawn at a different angle. It is both simple and correct to use such an arbitrary line to represent the azimuth line. Remember that the line itself does not change position, but its angular value is changed because of measurement from different reference directions.

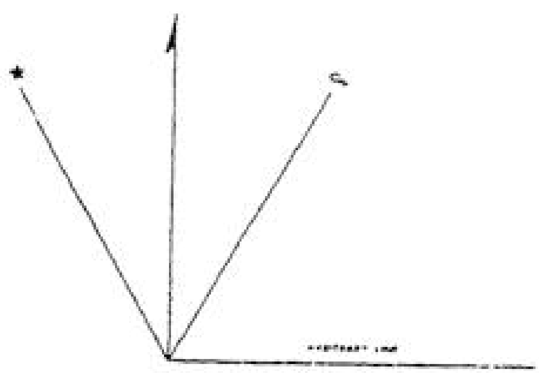

Figure 8-25. Declination Diagram With Arbitrary Line

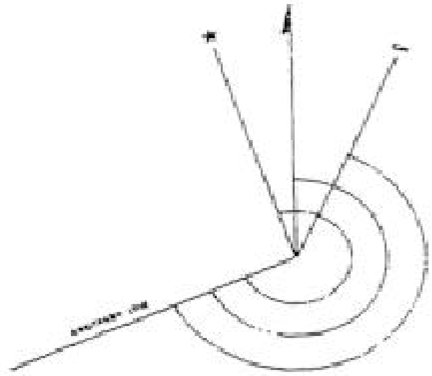

Figure 8-26. Declination Diagram With Arbitrary Line in a Different Position

c. Complete the diagram by drawing an arc from each reference line to the arbitrary azimuth line. A glance at the completed diagram shows whether the given azimuth or the desired azimuth is greater, and thus, whether the known difference between the two must be added or subtracted (Figure 8-27).

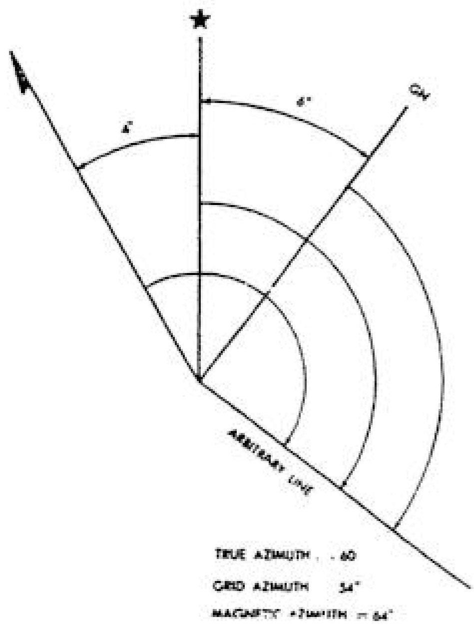

Figure 8-27. Azimuth-Angle Relationship

d. After the correct conversion rules have been determined, they should be noted in the map margin adjacent to the declination diagram for future reference.

8-18. **Given two locations on the map and a list of straight line distances, select the correct straight line distance between the two locations to within 100 meters.**

For EFMB purposes, you will be given a standard 1:50,000 topographic map. You can use this map to measure the distance between two places. The map is drawn to scale. The scale is printed at the top and bottom of the map. To measure the straight line distance (miles, meters, or yards), take a strip of paper and make a small tick mark on it. Line that tick mark up with one of the two points you are measuring between, line the paper strip up so the two points are in the line and place another tick mark at the second point. Then go to the bar scales on the map to get the distance.

8-19. **Given two locations on the map and a list of road distances, select the correct road distance between the two locations to within 200 meters.**

When finding the distance between point A and point B around a curve in a road, you repeat the procedures described for 8-15; but, instead of a straight line, pivot the paper so it continues to follow the edge of the road around the curve. Each time you pivot the paper place a tick mark so as not to lose your place. Then go to the bar scales to get the distance.

8-20. **Given a location, a grid or magnetic azimuth, a distance, and a list of locations, select the correct end location using the polar coordinate method of navigation.**

A point on the map may be determined or plotted from a known point by giving a direction and a distance along that direction line. This method of point location uses polar coordinates. The reference direction is normally expressed as an azimuth and the distance is any convenient unit of measurement such as meters or yards. The magnetic azimuth can be determined from the compass and the distance can be estimated.

8-21. **Given at least to known locations, grid or magnetic azimuths, and a list of unknown locations, select the correct unknown location using the intersection process.**

Intersection is used to locate features that are not defined on a map or which are not readily identifiable. There are two methods in which you can do this. The method you should use for the test is the straight edge method because you will not be using a compass during the written test.

The procedures are:

a. First locate your position on the map and mark it.

b. Lay a straight edge (a strip of paper) on the map with one end at your located position as a pivot point and rotate the straight edge until the unknown point is sighted along the edge.

c. Draw a line along the straight edge.

d. Repeat the above procedures at another known position and check for accuracy at a third position.

e. The intersection of the lines is the location of the unknown point.

NOTE

For test purposes, you will be asked to give the coordinates of the unknown positions

8-22. **Given at least two known location's, grid or magnetic azimuths, and a list of =known locations, select the correct unknown location using the resection process.**

Resection allows an individual to determine his exact location when it is not known by sighting on two or three known features. Again, you can do this by two methods, but for the written test use the following method:

a. Locate two or three known positions on the ground and mark them on your map.

b. Lay a straight edge on the map with the center of the straight edge at a known position as a pivot point and rotate the straight edge until the known position on the map is aligned with the known position on the ground.

c. Draw a line along the straight edge away from the known position on the ground toward your position.

d. Repeat b. above using a second known position; check your accuracy by repeating b. above using a third known position.

8-23. **Given at least two known locations, grid or magnetic azimuths, and a list of unknown locations, select the correct unknown location by intersecting one leg and resecting one leg.**

Study the text from FM 21-26, Map Reading, Objectives for 8-18 and 8-19.

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